

Basic Studies of Ion Sputtering

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Motivation

- Particle-solid interactions are important for nanotechnology
 - To extend mass analysis to nanoparticles and features
 - For improving fabrication techniques (e.g., FIB etching, ion implants and ion beam damage)
- Fundamental changes in particle solid interactions are expected for nanoscale particle-solid interactions
 - Sputtering yields may vary due to the many steps and terraces on nanoparticles
 - What happens when the dimensions of a collision cascade exceeds the dimensions of nanoparticle?

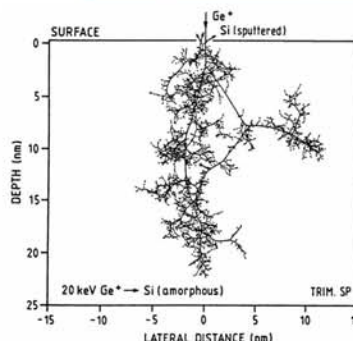
Accomplishments

- Laser post ionization secondary neutral mass spectrometry (LPI SNMS) was applied to the study of particle-solid interactions.
 - We were the first to determine the depth of origin of sputtered atoms from a solid surface.
 - The velocity and angular distributions of sputtered neutrals have been measured and used to verify the binary collision model of sputtering.
 - Electronic and vibrational energy partitioning among sputtered atoms and molecules have been measured.
 - We were first to discover and characterize large neutral clusters originating from a sputtered surface.
- We have developed a new highly sensitive LPI SNMS instruments which may be the only means for characterization of sputtering on the nanoscale.
 - The high sensitivity allows individual nanoparticles and one-of-a-kind nanoscale features to be analyzed.
 - The high sensitivity is required for "static mode" analyses, since low ion dose is needed to investigate undamaged surfaces.

Future Directions

- Characterization of the neutral sputtered flux from nanoparticles.
 - Size specific arrays of nanoparticle on substrates will be produced by
 - Dispersion on surfaces from suspensions
 - In situ fabrication using etching and annealing
 - The same characteristic determined for "macro" targets will be measured as a function of particle size.

Transport of Ions in Matter (TRIM) Calculation



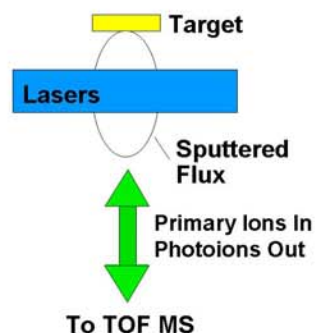
From a single ion impact (20 keV Ge⁺ shown at left)

- As many as 18 surface atoms are affected.
- The collision cascades extend 10-20 nm in depth and width.

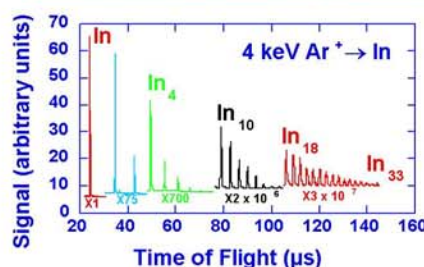
What will happen when the impact occurs on a 5 nm particle?

Laser Post Ionization of Sputtered Neutrals

- A pulsed primary ion beam strikes a target surface causing sputtering
- The mostly neutral flux ejected from the surface is ionized by one or more lasers
- The photoions are detected by a time-of-flight mass spectrometer

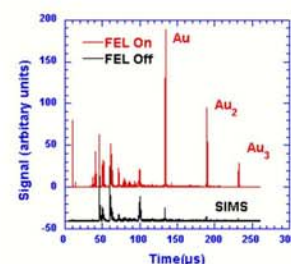
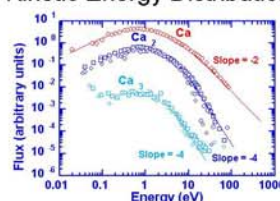


Characterization of Sputtered Neutral Flux



Measuring the abundance of neutral clusters in sputtered flux

Kinetic Energy Distributions



I. V. Veryovkin, W. F. Calaway, J. F. Moore, M. J. Pellin, J. W. Lewellen, Y. Li, S. V. Milton, B. V. King, M. Petravic, *Appl. Surf. Sci.*, 231 (2004) 962-966.